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Research Article

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Sustaining the productivity of sesame (*Sesamum indicum* L.) grown in Onattukara sandy soil through the application of sulphur and boron

■ JEENA MATHEW AND SUMAM GEORGE

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MEMBERS OF RESEARCH FORUM:

Corresponding author :
JEENA MATHEW, Central Plantation Crops Research Institute, Regional Station, KAYAMKULAM (KERALA) INDIA
Email: jeenu8@yahoo.com; jeenu15@gmail.com

Co-authors :
SUMAM GEORGE, College of Agriculture, VELLAYANI (KERALA) INDIA

Summary

Sulphur and boron have been found to act in a synergistic manner for enhancing the yield and quality of sesame (*Sesamum indicum* L.). As it is the choice crop of farmers in the summer rice fallows of Onattukara, field experiments were laid out in factorial RBD with four levels each of sulphur and boron with the variety Thilarani. The levels of sulphur tried were 0 kg S ha^{-1}, 7.5 kg S ha^{-1}, 15.0 kg S ha^{-1} and 30.0 kg S ha^{-1} and 0 kg B ha^{-1}, 2.5 kg B ha^{-1}, 5.0 kg B ha^{-1} and 0, 2.5, 5.0 and 7.5 kg B ha^{-1} for boron which were applied as gypsum and borax, respectively. The incubation study, designed to understand the release pattern of nutrients reveled that highest quantity of sulphur and boron were available during the 30th day of incubation and there after showed a decreasing trend. Application of sulphur @ 30 kg ha^{-1} and boron @ 7.5 kg ha^{-1} improved the available nutrient status of Onattukara soil. The nutrient use efficiency of sulphur was highest at 30 kg ha^{-1} and that for boron it was 2.5 kg ha^{-1}. It also registered a significant positive impact on enhancing the yield and yield attributes of sesame in such a way that the highest rates of both the nutrients registered maximum yield from the crop in both the years.

Key words : Boron, Onattukara sandy soil, Productivity, Release pattern of nutrients, Sesame, Sulphur

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Introduction

Onattukara is the traditional sesame cultivating area of Kerala where an intensive multiple cropping is practiced with the cropping sequence: paddy-paddy-sesame. This tract comprises a total area of 28 000 ha covering the taluks of Karunagappally, Karthikappally and Mavelikkara of Kollam and Alleppy districts in Kerala. Sulphur and B are the two essential nutrients which have been proved to be playing a synergistic role in enhancing the yield and yield attributes especially with regard to the oil seed crops as that of sesame. Application of S and B together can improve the soil properties and thereby increase the yield of sesame in Onattukara region.

Resource and Research Methods

The experiment was conducted in two stages consisting of an incubation study and two field

experiments. The incubation study was done for studying the pattern of release of S and B to the soil at periodic intervals to be taken as an indication of the availability of these nutrients to the crop at its different growth stages of 4- 5 leaf stage, branching, flowering and pod formation stage. The study was conducted during 2009 January in 42 Completely Randomized Design with four levels each of S and B applied as gypsum and borax as their sources, respectively. The levels of S were 0 kg S ha^{-1}, 7.5 kg S ha^{-1}, 15.0 kg S ha^{-1} and 30.0 kg S ha^{-1} and that of B were 0 kg B ha^{-1}, 2.5 kg B ha^{-1}, 5.0 kg B ha^{-1} and 7.5 kg B ha^{-1}. One kilogram each of soil was incubated for fifty days in plastic containers and maintained at field capacity through out the period of incubation by replenishing moisture lost by evaporation. The soils were sampled at 20, 30, 40 and 50 days of incubation which coincided with the crop growth stages of 4- 5 leaf stage, branching, flowering and pod formation stage which were analyzed for S and B.

The field experiments were conducted at the farm attached to Onattukara Regional Agricultural Research Station, Kayamkulam during the summers of 2008 and 2009. It is located at $9^o30'$ N latitude and $76^o20'$ East longitude at an altitude of 3.05 m above mean sea level. The soil belongs to Oxyaquic Quartzi Psamment subgroup. The treatment combinations were same as that of the incubation study.

The variety chosen for the field experiment was 'Thilarani', a high yielding variety of sesame widely popular in Onattukara region as a third crop in summer rice fallows. The textural composition of the soil includes coarse sand - 68.55 per cent, fine sand - 17 per cent, silt - 5.55 per cent, clay - 8.35 per cent. The chemical properties include pH-5.1, EC-0.3 dSm^{-1}, organic carbon-0.31 per cent, available P-6.5 kg ha^{-1}, available K- 62 kg ha^{-1}, exchangeable Ca - 0.48 cmol kg^{-1}, exchangeable Mg - 0.034 cmol kg^{-1}, available S - 10.2 kg ha^{-1}, available B - 0.18 ppm, Fe - 8.2 ppm, Mn-1.62 ppm, Cu-0.3 ppm, Zn - traces. The physico-chemical properties of the soil were estimated as per the standard procedures as outlined in Jackson (1973).

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of treatments on the biometric characters of sesame :

Influence of treatments on the biometric characters of sesame are presented in Table 1. Height of the plant at the time of harvest was significantly affected by the interaction of different levels of S and B. The highest value of 124.07 cm was recorded by T_{16} (S_3B_3) and was on par with T_9 (S_2B_0) and T_{13} (S_3B_0). The lowest value of 94.94 cm was recorded by T_1 (S_0B_0).

Among the different levels of S and B, S_3 (30.0 kg S ha^{-1}) and B_3 (7.5 kg B ha^{-1}) recorded the highest values of 117.31 cm and 115.34 cm. The lowest values recorded were 105.04 cm and 106.71 cm by S_0 (0.0 kg S ha^{-1}) and B_0 (0.0 kg B ha^{-1}).

Critical scrutiny of the data indicated that the interaction between different levels of S and B and the main effect of different levels of S were significant with regard to the number of secondary branches $plant^{-1}$ at the time of the harvest of the crop. Among the interaction effect, T_6 (S_1B_1) and T_{15} (S_3B_2) registered the highest value of 4.00 followed by T_2 (S_0B_1) and were on par with each other. The lowest value of 1.38 was shown by T_1 (S_0B_0).

Sulphur and boron have a favourable influence on the production phenology of oil seeds and the interaction between these nutrients enhances the growth characters of sesame. The enhanced chlorophyll synthesis and photosynthesis might have promoted the vegetative growth of the crop. Both S and B at increasing levels might have led to the increased biomass production at different crop growth stages and it was possibly due to the rapid conversion of synthesized carbohydrates into proteins and thus increased the number and size of cell which caused an increase in plant height and number of branches. The positive influence of S and B in enhancing the growth characters of sesame may be attributed to the better nutritional environment for plant growth at active vegetative growth stages as a result of improvement in root growth, cell multiplication, elongation and cell expansion in the plant body which ultimately resulted in increase in the height.

Considering the effect on root spread of sesame among the interaction effect of different levels of S and B, T_{16} (S_3B_3) recorded the highest value of 22 cm followed by T_{14} (S_3B_1) and T_{15} (S_3B_2) and were on par with each other. The lowest value of 7.2 cm was shown by T_1 (S_0B_0).

Among the different levels of S and B, S_3 (30.0 kg

S ha^{-1}) and B_3 (7.5 kg B ha^{-1}) recorded the highest values of 18.96 cm and 15.94 cm, respectively. The lowest values of 11.18 cm and 14.25 cm were shown by S_0 (0 kg S ha^{-1}) and B_2 (5.0 kg B ha^{-1}), respectively.

The positive influence of S on the root characters of soybean was reported by Zhao *et al*. (2008). Dell and

Table 1 : Effect of sulphur and boron on the biometric characters of sesame

Treatments	Height (cm)	No. of branches		Root characters		Length of internodes (cm)
		Primary	Secondary	Root spread (cm)	Root volume (ml)	
S_0 B_0	94.94	2.70	1.38	7.20	2.60	7.34
S_0 B_1	108.79	3.40	3.50	14.95	3.50	10.25
S_0 B_2	100.24	3.10	3.00	10.20	5.50	8.30
S_0 B_3	116.2	3.00	2.30	12.35	4.00	6.58
S_1 B_0	117.12	4.00	3.30	17.60	4.50	6.70
S_1 B_1	100.5	4.00	4.00	10.25	3.00	6.68
S_1 B_2	96.06	3.00	2.85	12.85	3.00	8.33
S_1 B_3	114.12	3.90	2.80	13.50	8.00	6.58
S_2 B_0	120.66	4.65	3.00	19.25	8.50	5.63
S_2 B_1	105.88	3.20	1.98	15.60	7.00	6.63
S_2 B_2	117.43	4.20	2.65	14.25	6.00	7.63
S_2 B_3	106.96	3.13	2.25	15.90	7.00	7.60
S_3 B_0	117.45	4.50	2.50	14.15	8.50	5.85
S_3 B_1	114.58	3.30	3.05	20.00	9.00	7.05
S_3 B_2	113.12	4.50	4.00	19.70	10.00	5.93
S_3 B_3	124.07	4.50	2.88	22.00	11.00	6.68
S_0	105.04	3.05	2.47	11.18	4.00	8.11
S_1	106.95	3.73	3.11	13.55	4.65	7.07
S_2	112.73	3.79	2.54	16.25	7.13	6.87
S_3	117.31	4.20	3.24	18.96	9.50	6.38
B_0	106.71	3.48	2.54	14.55	5.63	6.38
B_1	107.44	3.96	3.13	15.20	6.00	7.65
B_2	112.54	3.70	3.13	14.25	6.03	7.54
B_3	115.34	3.63	2.56	15.94	7.63	6.86
F-S	4.25*	4.28*	3.96 *	9.78 **	22.42 **	2.60^{NS}
F-B	3.52*	0.778^{NS}	2.91^{NS}	3.42*	2.81^{NS}	1.76^{NS}
F-SxB	2.63*	1.69^{NS}	2.88*	2.65*	2.632*	1.23^{NS}
CD(S)	8.167	0.694	0.589	3.243	1.599	-
CD(B)	8.167	-	-	3.243	-	-
CD(SxB)	16.334	-	1.180	6.487	3.197	-

* and ** indicate significance of values at P=0.05 and 0.01, respectively NS= Non-significant

Huang (1997) through their research findings concluded that B plays a primary role in cell enlargement and secondary role in cell division both together contributing to the elongation of roots.

Effect of S and B on the yield and yield attributes of sesame :

Days to first and fifty per cent flowering :

It can be observed from the data that the interaction between different levels of S and B had significant effect on the days to first flowering and also on the fifty per cent flowering of the crop. The treatments which received S at 30 kg ha^{-1} and B at 2.5 kg ha^{-1} were the first to flower at 33 DAS. Plants which received neither S nor B were the last to flower among all the treatments. They flowered at 37 DAS. The same trend was observed with regard to the days to attain the stage of 50 per cent flowering. The values ranged between 36.00 and 46.00 being shown by T_{14} (S_3B_1) and T_1 (S_0B_0), respectively. This observation is much relevant for a crop like sesame because harvesting at proper maturity is absolutely essential to have a commendable yield from the crop since over maturity leads to shattering of grains. Moreover, since this is grown as a catch crop in the summer season after two crops of paddy, attaining maturity at an early date will make the field available to farmers for operations of the subsequent paddy crop (Table 2).

Grain yield :

The grain yield of sesame was significantly influenced by the interaction between S and B in both the field experiments. Among the interaction effect, the highest value of 1460.94 kg ha^{-1} was recorded by T_{16} (S_3B_3) followed by T_{14} (S_3B_1) which were on par with each other. The lowest value of 585.94 kg ha^{-1} was recorded by T_1 (S_0B_0). For the second crop also analysis of the data shows the significant influence of the

Table 2 : Effect of S and B on the yield attributes of sesame

Treatments	Days to first flowering	Days to fifty per cent flowering	Seed yield (kg/ha)	Bhusa yield (t ha^{-1})	Harvest index
$S_0 B_0$	37.00	46.00	561.72	13.63	0.417
$S_0 B_1$	34.50	39.00	1108.67	19.59	0.621
$S_0 B_2$	34.00	39.00	1056.51	22.85	0.565
$S_0 B_3$	34.50	40.00	980.33	13.67	0.555
$S_1 B_0$	36.50	40.00	733.59	14.72	0.313
$S_1 B_1$	32.00	36.00	1025.89	14.65	0.404
$S_1 B_2$	33.00	38.00	953.65	14.99	0.416
$S_1 B_3$	34.50	40.50	1087.76	21.59	0.211
$S_2 B_0$	35.50	44.00	1008.33	22.48	0.226
$S_2 B_1$	33.00	37.00	1017.44	14.02	0.391
$S_2 B_2$	34.00	39.00	1128.13	23.30	0.304
$S_2 B_3$	33.00	41.50	1031.77	18.27	0.353
$S_3 B_0$	34.00	40.00	951.04	17.63	0.339
$S_3 B_1$	33.00	36.00	1275.27	25.92	0.242
$S_3 B_2$	34.00	38.00	895.05	15.0	0.187
$S_3 B_3$	33.00	38.50	1434.12	19.93	0.383
F-SxB	3.3805*	2.95*	25.66 **	2.85*	649.76**
CD(SxB)	2.52011	3.484	30.52	14.04	0.2952

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Effect of S and B on the nutrient use efficiency in Onattukara sandy soil

Levels of S (kg ha^{-1})	S Use efficiency	Levels of B	B Use efficiency
7.5	3.91	2.5	124.48
15	6.68	5.0	43.14
30	8.33	7.5	41.15

interaction between different levels of S and B and their individual effects. Among the interaction effect as in the case of the first crop, the highest value of 1407.30 kg ha^{-1} was recorded by T_{16} (S_3B_3) and was significantly superior to other treatment combinations. This was followed by T_{14} (S_3B_1). The lowest value of 537.50 kg ha^{-1} was recorded by T_1 (S_0B_0). All the treatments recorded significantly higher values than it. The pooled data for both the years also revealed the significant effect of the interaction between different levels of S and B. The highest value of 1434.12 kg ha^{-1} was indicated by T_{16} (S_0B_0). This was significantly superior to the other treatment combinations. The lowest value of 561.72 kg ha^{-1} was recorded by T_1 (S_0B_0). The increase in seed yield was due to the stimulatory effect on the synthesis of chloroplast and protein which in turn promoted greater photosynthesis ultimately resulting in higher yield over control. Higher availability of soil nutrients might also contributed to the better yield of sesame. The efficiency of sulphur applied as phosphogypsum on enhancing the yield and yield attributes of cowpea was reported by Mathew (2003). Saren *et al*. (2004) found that the grain and bhusa yield of sesame increased due to increasing levels of S which they ascribed to the uniform distribution of S in the rhizosphere. The positive influence of S and B in improving the yield and yield attributes of sunflower was reported earlier by Shekawat and Shivay (2008).

Considering the effect of boron, carbohydrate metabolism might had been stimulated which favored the increase in seed yield. Improvement in leaf area might also be responsible for the observed parallel increase in various yield characters. These results are in agreement with the findings of Sarkar and Saha (2005).

The improved nutritional management as a result of the increased supply of S and B might have favaourably influenced the carbohydrate metabolism and this favourable effect led to the increased transformation of photosynthates towards yield and yield attributing characters. These results corroborates the findings of Saren *et al*. (2004) and Shekawat and Shivay (2008).

Critical evaluation of the data on the harvest index of the crop showed that the highest value among the different levels of the nutrients was shown by S_3 (30.0 kg S ha^{-1}) and B_1 (2.5 kg B ha^{-1}). Trend was the same as in the case of the grain yield. Hence, we can infer this as the most favourable combination for obtaining maximum yield and yield attributing characters of sesame.

Effect of S and B on the nutrient use efficiency :

S use efficiency :

The yield improvement over unit quantity of S addition was calculated as S use efficiency. Critical examination of the data showed that the different levels of S tried had influence on S use efficiency (Table 3).

An increasing trend was observed for S use efficiency and the highest value of 8.33 was observed in S_3 (30.0 kg ha^{-1}) and the lowest value of 3.91 was shown by S_1 (7.5 kg S ha^{-1}). At higher levels of S application, the absorbed nutrients are efficiently utilized for grain formation. Similar result was reported by Sarkar and Saha (2005) and Piri and Sharma (2006).

B use efficiency :

In the case of B use efficiency, B_1 (2.5 kg B ha^{-1}) recorded the highest value of 124.48 and showed a decreasing trend with increase in the level of applied B. Hence, we can conclude that efficient utilization of B in sesame is facilitated only up to 2.5 kg ha^{-1} and beyond which a negative trend is noticed which may be due to the ionic imbalance within the plant. The range between deficiency and sufficiency is very narrow for boron.

Conclusion :

Onattukara sandy soil is best with several soil constraints in terms of deficiency of nutrients, poor nutrient and water holding capacity and low organic matter status. This traditional sesame growing area has immense scope for intensive cultivation if managed with the application of adequate quantities of nutrients. Sesame, the oldest of the cultivated crop by man can definitely find a place in the cropping sequence following the two crops of paddy. It can be concluded form the experiment that application of S and B in the Onattukara sandy soil will improve the yield of sesame as well as the nutrient use efficiency in sesame, thereby the production potential of this type of soil can be sustained so as to raise other crops subsequently.

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